HYDROGEOLOGIC FRAMEWORK OF EASTERN JEFFERSON COUNTY: IMPLICATIONS FOR SURFACE WATER–GROUND WATER INTERACTIONS

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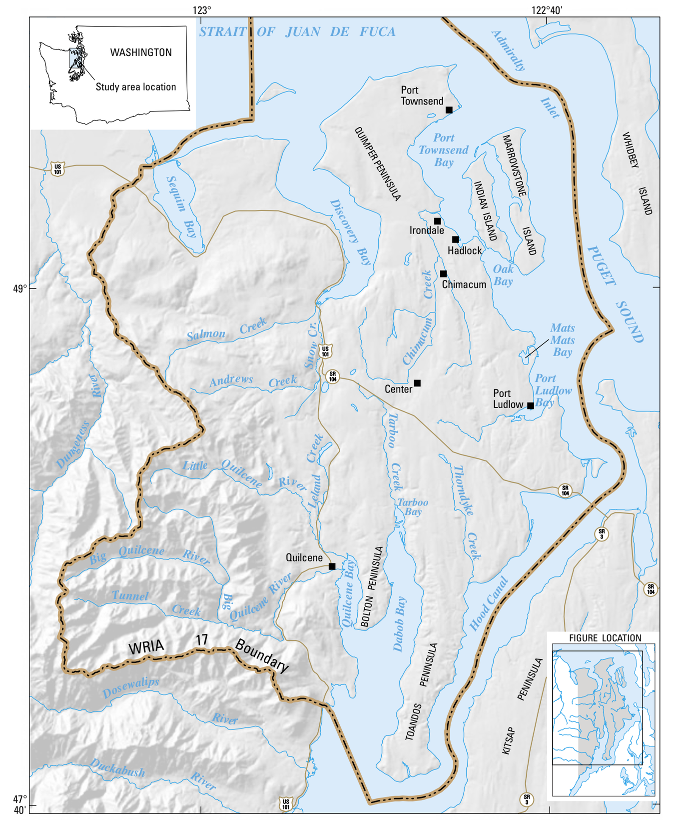
The hydrogeologic framework and interactions between surface water and ground water were determined as part of a study of the water resources in the Chimacum Creek Basin and other significant drainages within eastern Jefferson County. The study will assist local watershed planners in assessing the status of water resources and the potential impacts of ground-water development on surface-water systems.

The surficial geology of the Chimacum Creek Basin was compiled from existing sources, modified using LIDAR imagery, and used along with drillers' logs from more than 110 wells to define the hydrogeology. Quaternary glacial deposits, which are as much as 900 feet thick and overlie bedrock, form four hydrogeologic units: the Vashon recessional outwash aquifer, the Vashon till confining unit, the Vashon advance outwash aquifer, and the older glacial sequence. The Vashon advance outwash aquifer is the most productive source of ground water in the area, although ground water is found throughout the glacial deposits in discontinuous lenses of sand and gravel.

Time-synchronous stream-discharge measurements made in June and October 2002 were used to identify reaches of Chimacum Creek, and its tributaries, the lower reaches of the Big and Little Quilcene Rivers, and Tarboo Creek, that were gaining and losing water to the ground-water system. Vertical hydraulic and thermal gradients measured with in-stream mini-piezometers and piezometers with nested temperature sensors provided additional data to refine the boundaries between gaining and losing reaches and define seasonal variations in surface-water/ground-water exchanges. Each of the creeks examined had a unique pattern of gaining and losing reaches that reflect changes in the geology or transmissivity of the material underlying the streambed. Significant surface-water losses were found at transitions between Quaternary, valley-filling peat deposits and recessional outwash on Chimacum Creek and on the alluvial plain near the mouths of the Big and Little Quilcene Rivers. Seasonal variations in the magnitudes of gains and losses were likely the result of changes in the altitude of the surrounding water table relative to river stage.

Chimacum Creek and Tarboo Creek Basin in WRIA 17



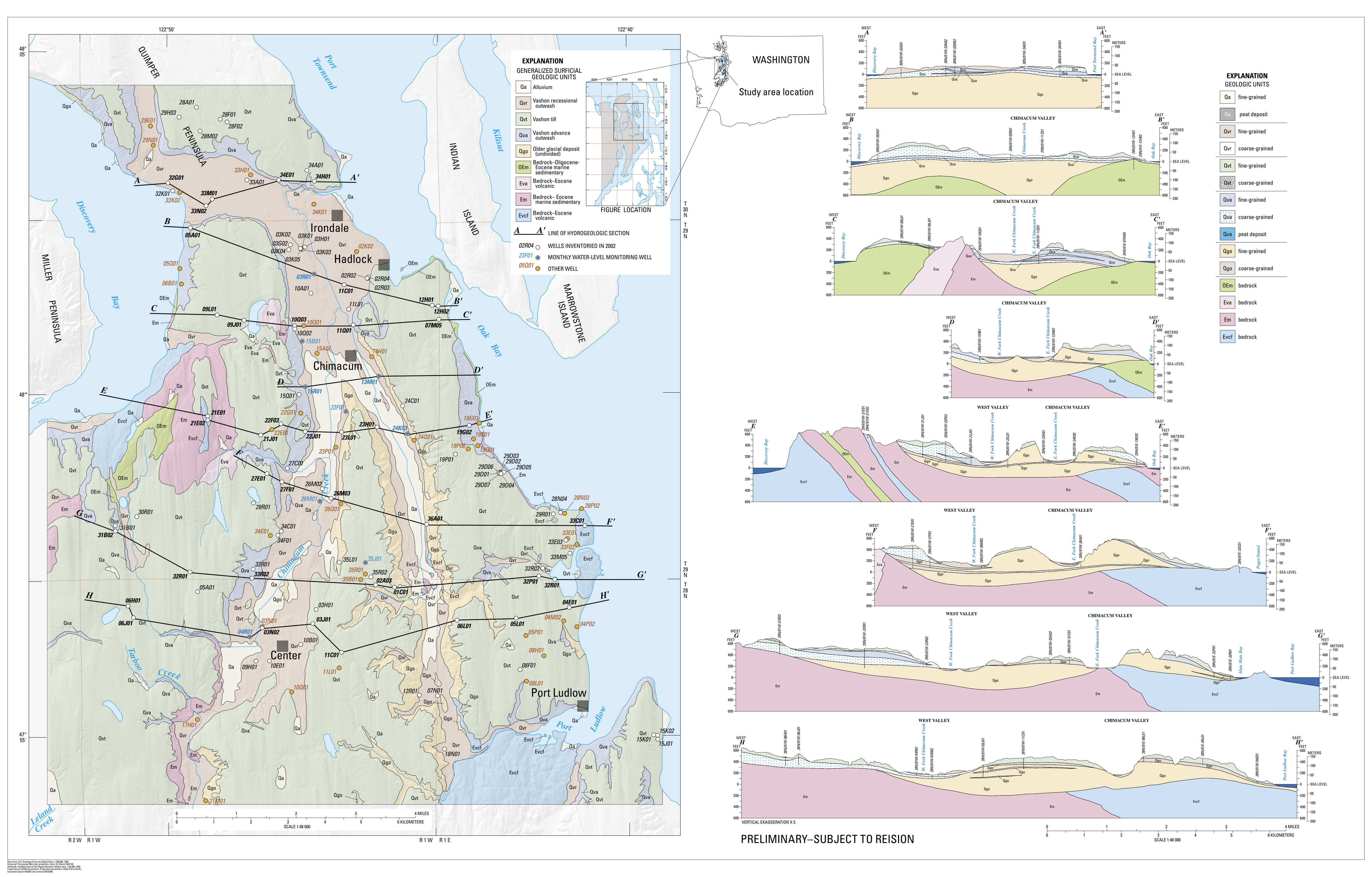
The hydrogeologic framework of the Chimacum Creek Basin in eastern Jefferson County was developed by integrating existing geologic mapping, newly acquired LIDAR imagery, and driller's logs from 110 inventoried public and private wells.

Once the geologic framework was characterized, derivative maps were generated. Bedrock elevations were inferred from projections of surface outcrops, minimum thickness of unconsolidated deposits recorded in driller's logs, and published depth-to-bedrock maps for Puget Sound (Jones, 1996). Isopach maps (not shown here) were generated for Qva and Qgo hydrogeologic units using driller's logs and previously published data (Grimstad and Carson, 1981). Water-level altitudes were measured as part of the well inventory. Water-table elevations were contoured and flow directions were inferred. Nine wells were selected for monthly water-level measurements so that seasonal variations could be monitored.

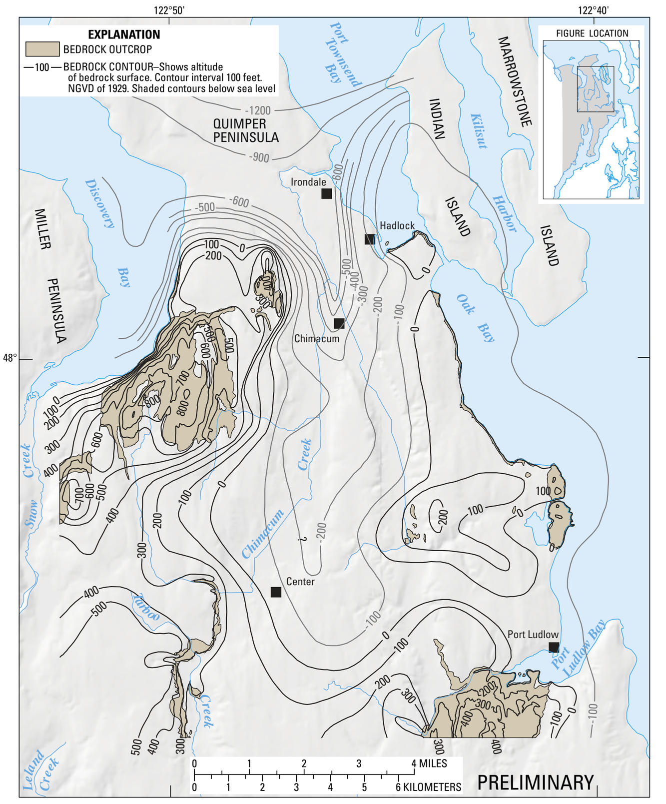
Jones, M. A., 1996, Thickness of unconsolidated deposits in the Puget Sound lowland, Washington and British Columbia: U.S. Geological Survey Water-Resources Investigation Report 94-4133, 1 plate, scale 1:500,000.

Grimstad, Peder, and Carson, R.J., 1981, Geology and ground-water resources of eastern Jefferson County, Washington: Washington State Department of Ecology Water-Supply Bulletin No. 54, 125 p

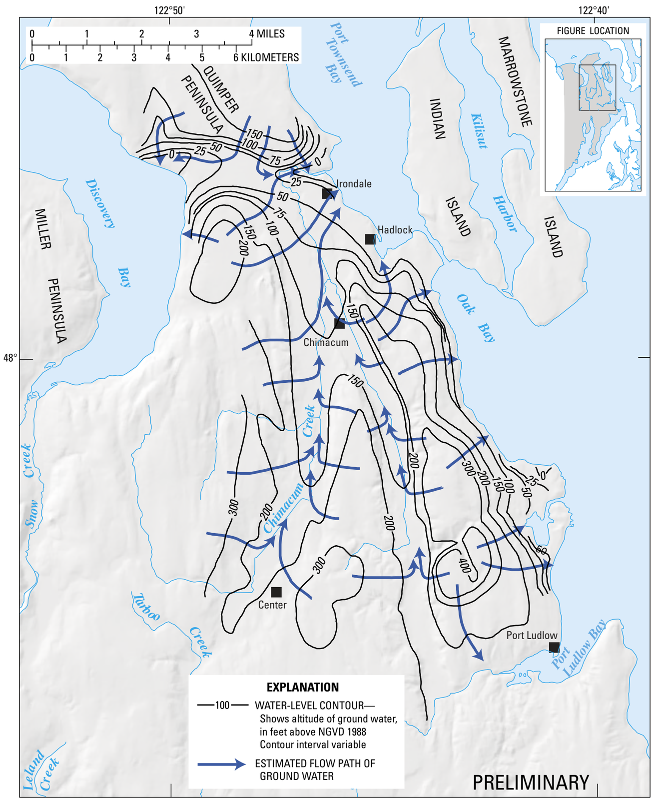
Map and hydrogeologic sections showing location of inventoried wells, surficial geology, and hydrogeologic units in the Chimacum Creek basin, eastern Jefferson County, Washington



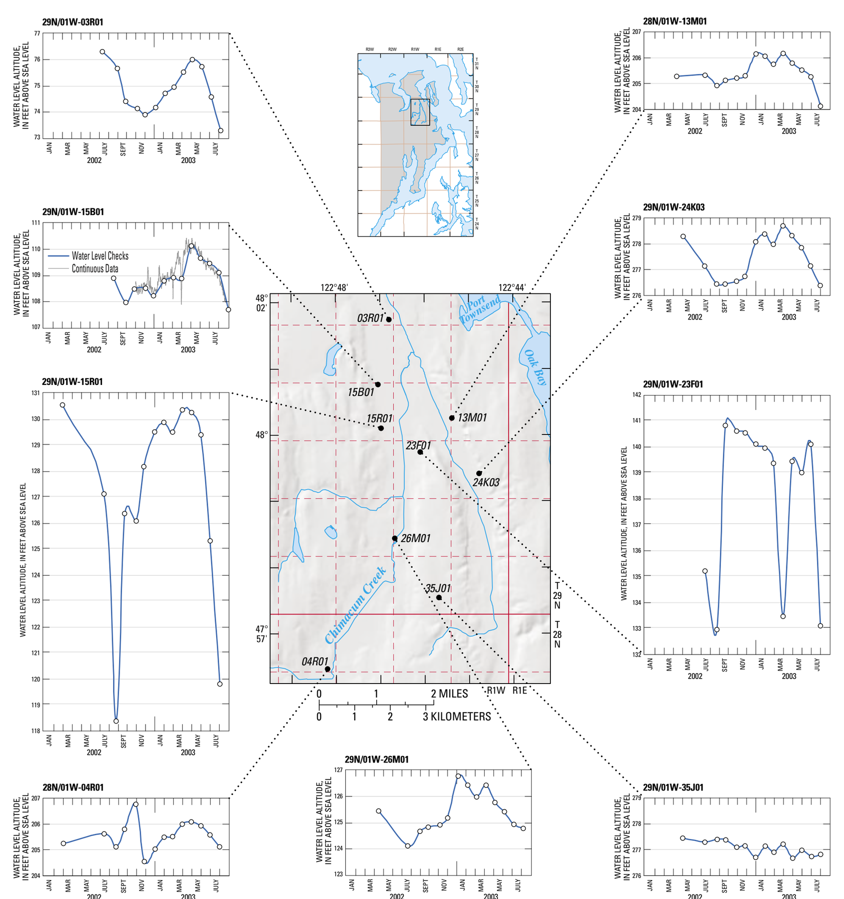
Interpreted altitude of bedrock



Ground-water-level altitude and estimated flow paths or aquifers within Qva and Qgo

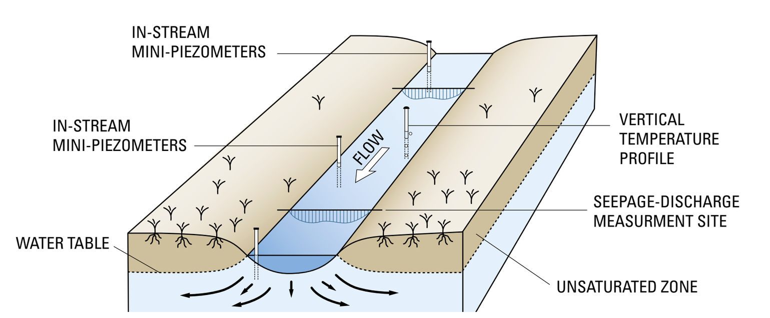


Locations of monthly monitoring wells and their respective hydrographs

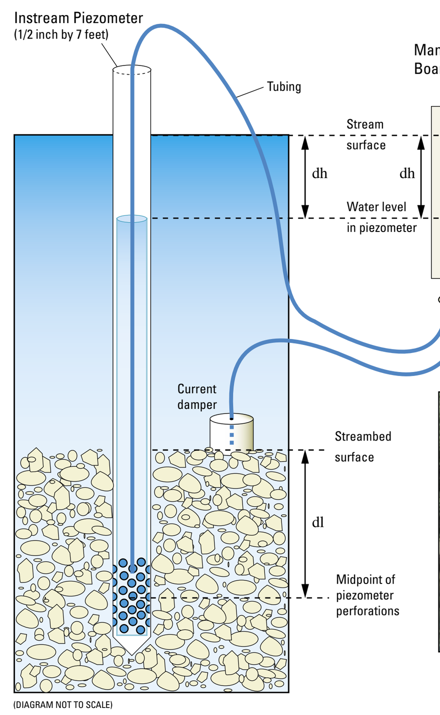


In order to understand how exchanges occur between surface water and ground water, four watersheds were studied in detail; these include Chimacum Creek, the Big Quilcene River, the Little Quilcene River and Tarboo Creek. Because no single technique can definitively quantify how exchanges occur, this study used a combination of methods to define the spatial distribution, the seasonal variations, and the quantity of water being exchanged for each drainage basin. Seepage runs provided information about the quantity of water being exchanged while the combination of seepage runs and in-stream mini-piezometers provided data to define the spatial distribution of gaining and losing reaches. Multiple seepage runs and periodic mini-piezometer surveys combined with continuous vertical temperature profiles provided temporal information to assess seasonal variations. Taken together, these techniques provide a more complete picture of the exchanges between surface water and ground water that occur within a given watershed. Data for each of the drainage basins are presented below.

Integration of methods

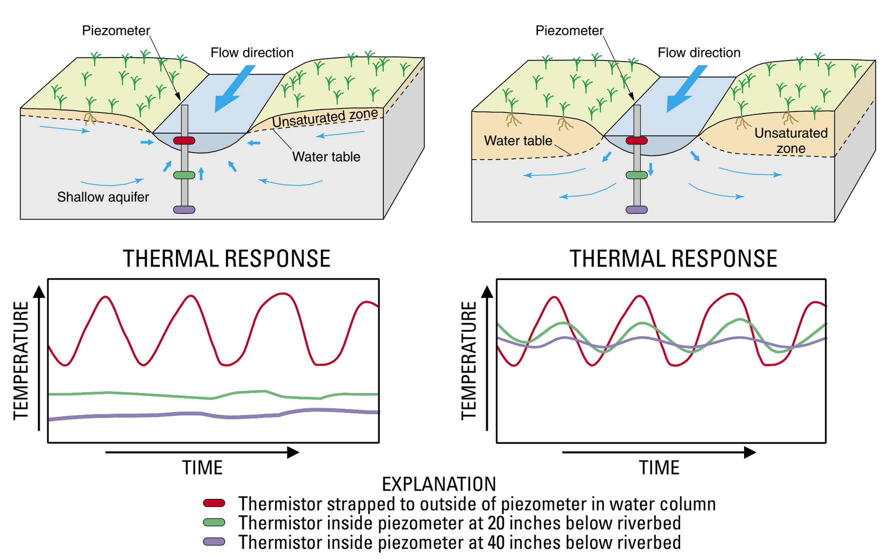


How a manometer board is used to measure hydraulic head differences throughout a streambed

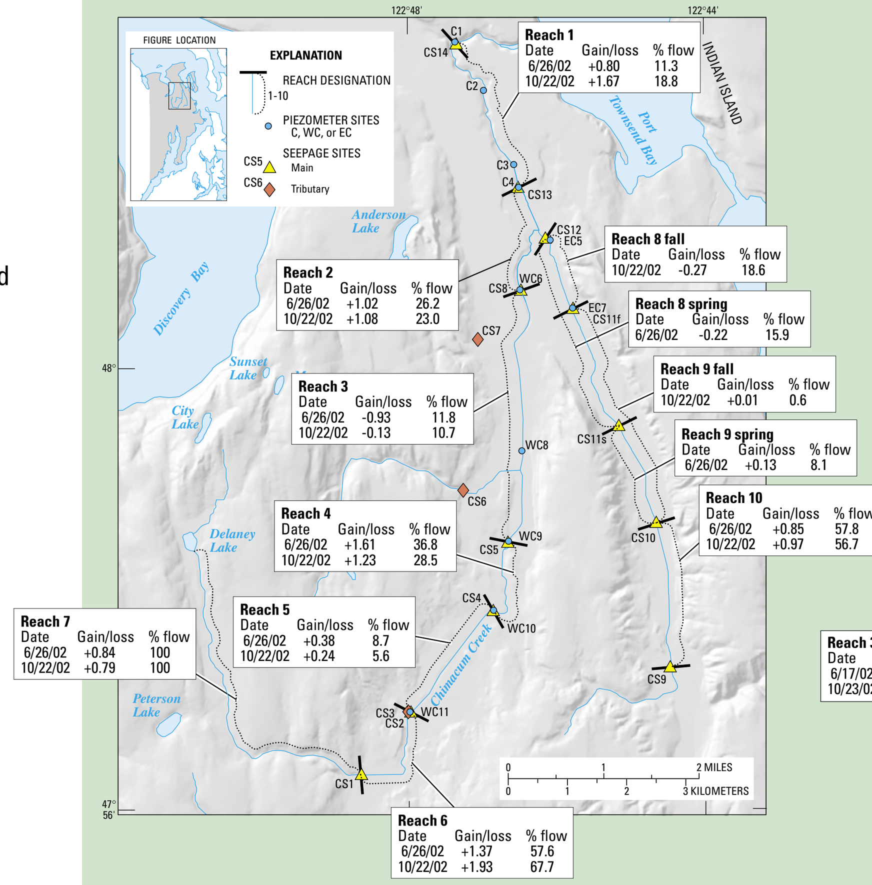


Hydrologist using a manometer board to measure head differences between surface water and ground water.

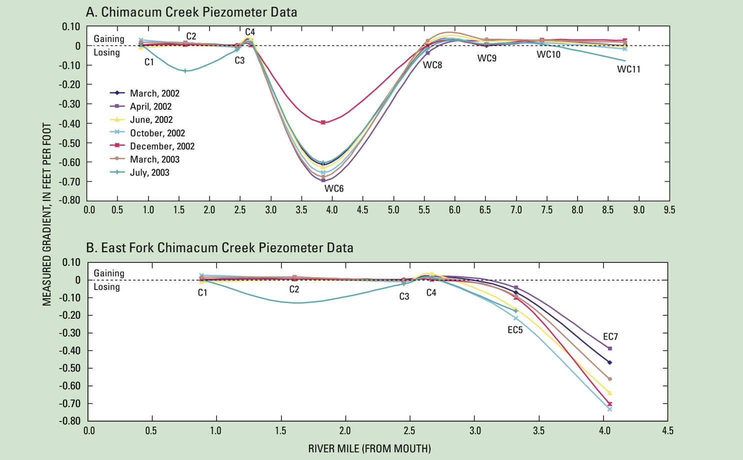
Surface- and ground-water relations and thermal response in streambeds for representative gaining reaches and losing reaches



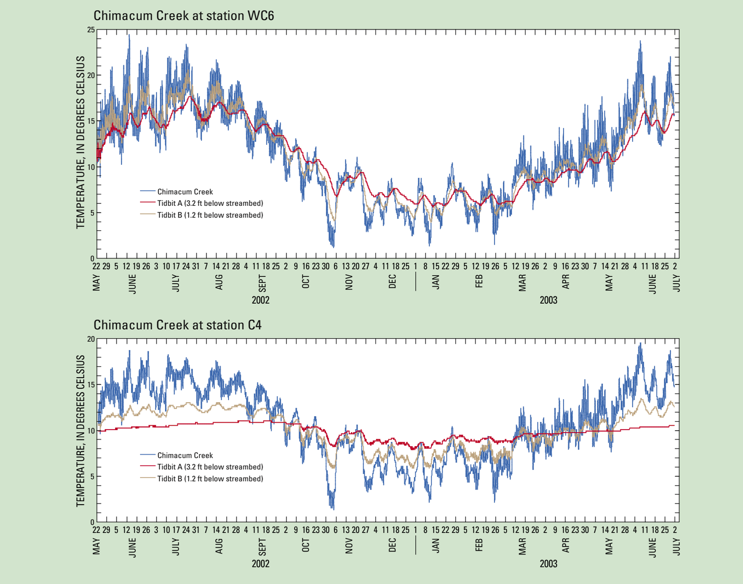
Locations of mini-piezometers and seepage runmeasurement sites in the Chimacum Creek basin



Mini-piezometer data for Chimacum Creek



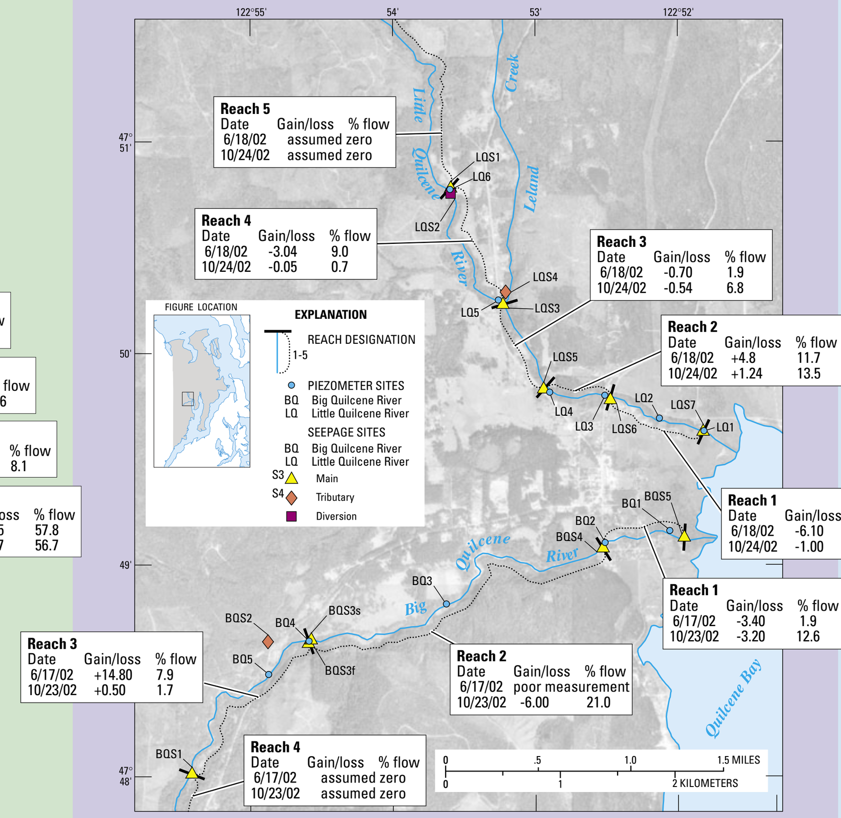
Thermographs showing continous vertical temperature profiles

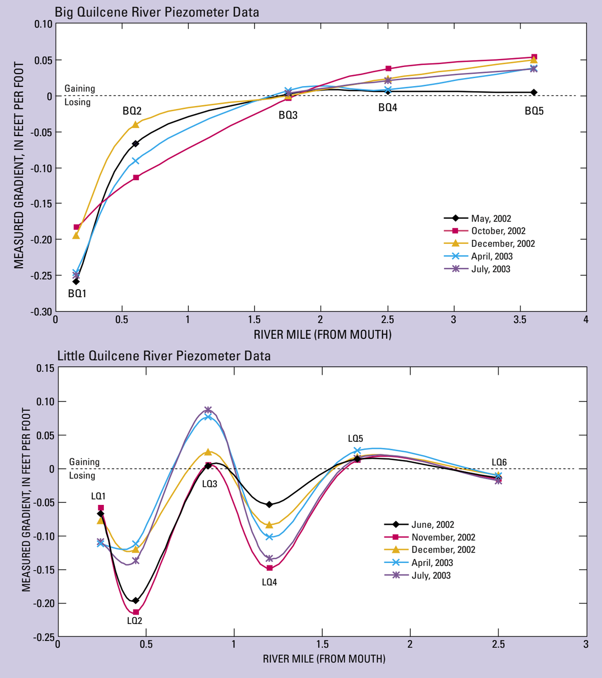


Preliminary conclusions

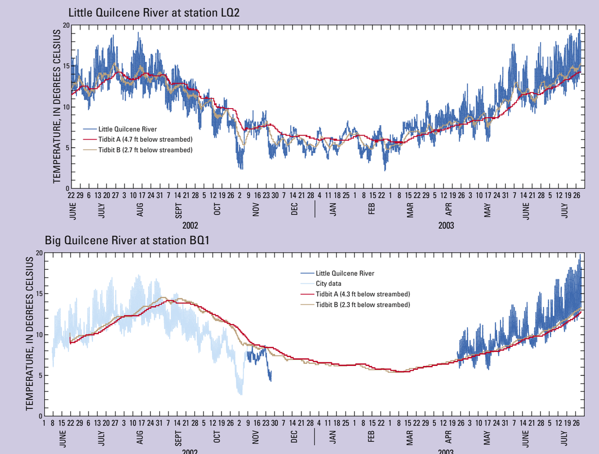
The upper reaches of Chimacum Creek were found to gain water from the ground water system (probably from aquifers within Qva and Qgo). Little ground water exchange occurs as the creek flows over peat deposits until the creek encounters Qvr where it loses water through the streambed near the community of Chimacum. Gaining conditions occur farther downstream where the creek is incised into Qvr and the local water table is higher than the average stream stage. Locally, winter stream stages are sufficiently higher than the local water table to cause the creek to lose water to the ground water system. The net exchange between ground water and Chimacum Creek observed in this study was a gain of about 6 cfs.

Mini-piezometer data for Big and Little Quilcene Rivers



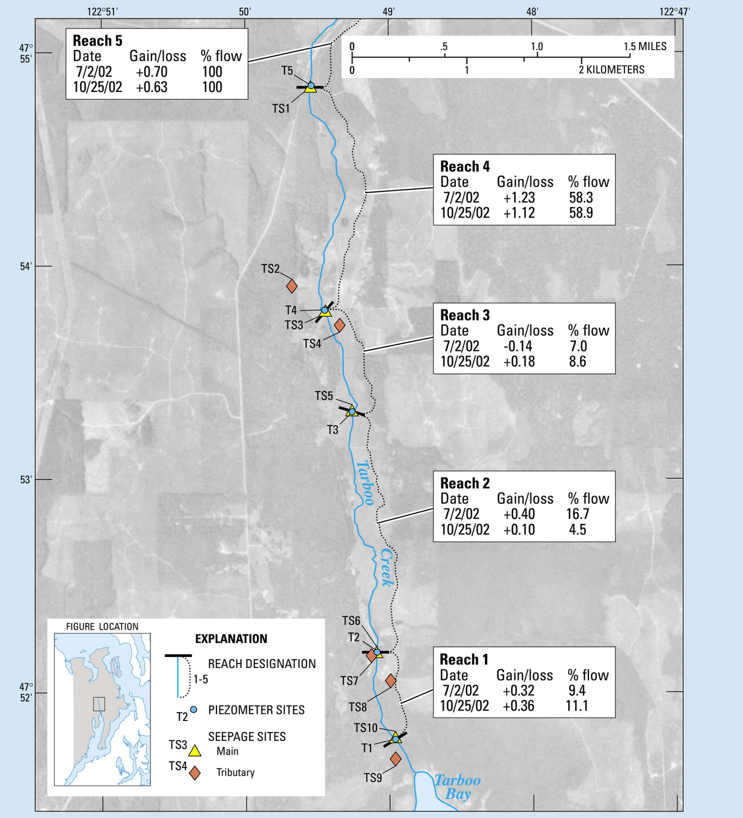


Thermographs showing continous vertical temperature profiles

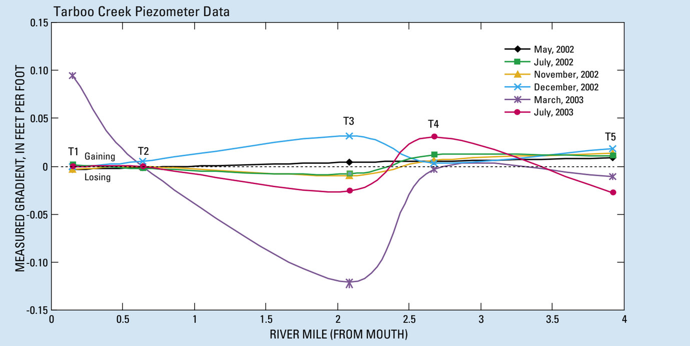


The Big Quilcene River gains water from the ground water system where the streambed is in contact with very coarse boulder, gravel alluvium. Ground water enters the river in the vicinity of Penny Creek and just downstream from highway 101. Below the gaining reach where the river flattens out and the flood plain widens, the river passes through a transition zone where little or no ground water exchange occurs. The lower reaches of the river are characterized by losing conditions throughout the year. The net exchange between ground water and the Big Quilcene River observed in this study was dependent upon river flow and ranged from a gain of about 11.4 cfs to a loss of about 8.7 cfs.

Mini-piezometer data for Tarboo Creek



Mini-piezometer data for Tarboo Creek



Tarboo Creek gains water from the ground water system in its upper reaches where the streambed is in contact with water bearing horizons within Qva and Qvr. The middle reaches of Tarboo Creek appear to be a transition zone where gaining or losing conditions may depend upon precipitation events which affect altitudes of stream stage relative to the adjacent water table. Although the seepage data suggests that the lower reaches of the creek may gain small amounts of water, the mini-piezometer data suggest little or no ground water exchange. The net exchange between ground water and Tarboo Creek observed during the course of this study was a gain of about 1.75cfs.

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The Little Quilcene River loses water once the river leaves its bedrock channel and the streambed comes into contact with alluvial deposits. As the river flows south towards the community of Quilcene it continues to lose water except for a localized area near the mouth of Leland Creek where gaining conditions exist. The river also gains water just upstream from Center Road but then loses water as it flows across the alluvial plain at the head of Quilcene Bay. Losing conditions persist throughout the year similar to the lower reaches of the Big Quilcene River. The net exchange between ground water and the Little Quilcene River found in this study was also dependent upon river flow and ranged from a loss of about 0.35 cfs to a loss of about 5 cfs.